Instrumentation for Beam Experiments

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for the HF Instrumentation Group

How we understand our Job

- Understand what needs to be measured
- Understand what can be measured
- Build the instrument
- Interface the instrument to the Control System
- Develop users among the AP and Operator communities
  - During commissioning
  - During beam experiments
  - During normal operations
- Iterate

Outline by Instrument

- ***BPM system***
- PLL
- LF Schottky
- HF Schottky
- Quadrupole Monitor
- Emittance (Roger Connolly) – IPM, Schottky, QMM, moveable BPM, wire scanner?,…

BPMs – the competition

- The workhorse
  - Well integrated into the Control System
  - ~ 600 planes, TBT data on a single bunch, million turns on 8 planes
  - Improved timing (auto-time at inj), auto-gains, reliability analysis,…
  - Lots of AP horsepower, permits local corrections,…
- On the horizon (January? February?) – 'SNS' BPM
  - Custom AFE/Digitizers/FPGA/PCI interface/timing decoder
  - Clocked at 3x 28MHz RF (4x?), pre-processing in FPGA
  - **'continuous'** TBT data for **every** bunch? ~10MB/sec to PCI
  - Sum signal is 'DCCT/WCM'? 'WCCT'? Longit and transverse instab?
  - Controls Interface? LabVIEW for now?

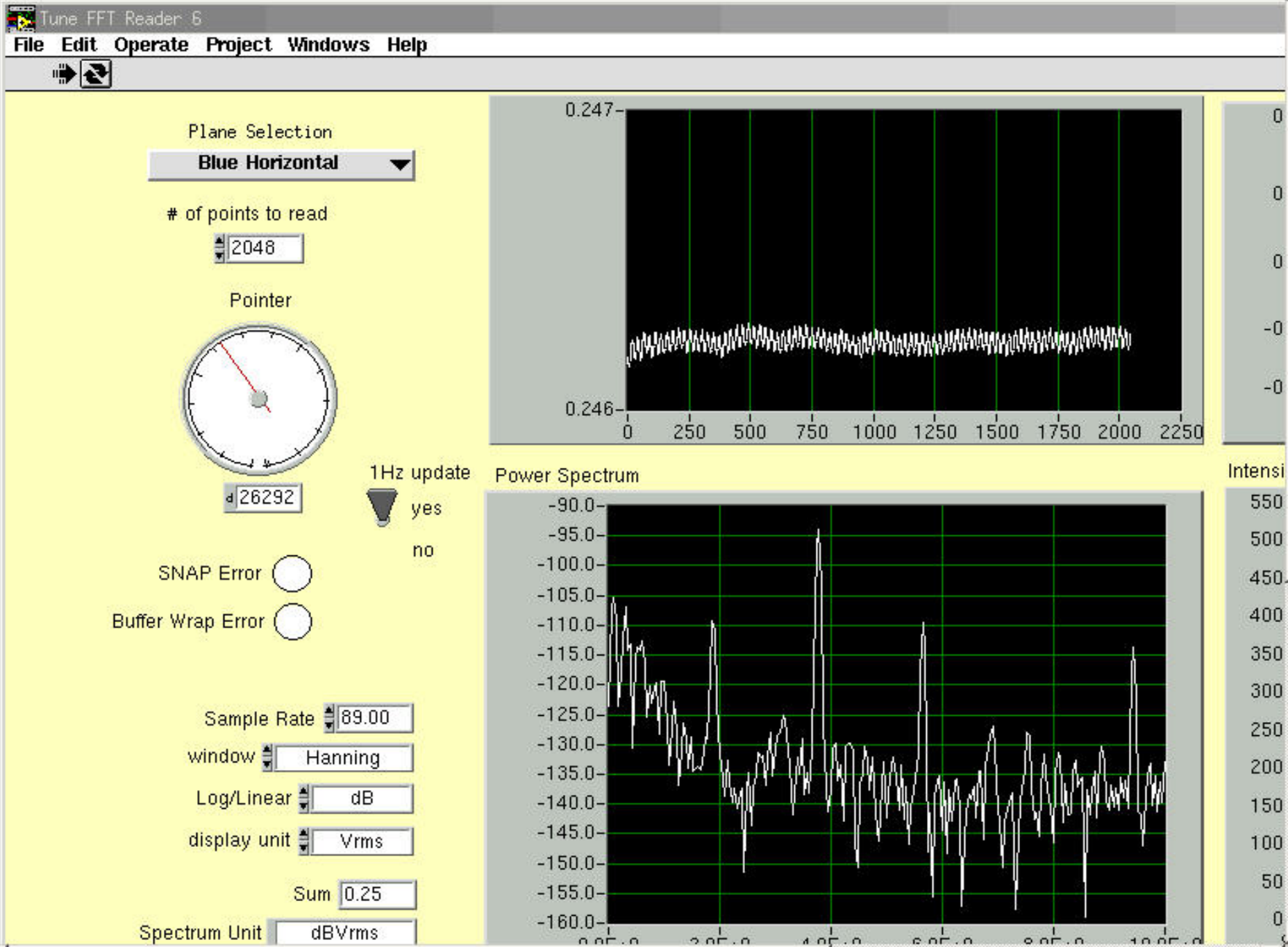
p - passive	WCM/	BPM	IPM	HF	LF	Spectrum	QMM	INJ	PLL	BTF	AC	ARTUS	BLM
b - bkgrnd	DCCT			Sch	Sch	Analyzer		Osc		non-res	Dipole		
a - active										PUE			
tune		p		p	p	p		b	b		a, b	a	
coupling		p		p	p	p		b	b		a, b	a	
chrom		head-tail		p	p	p		b	b			a	
β, D		p						b			a, b	a	
emittance	p	moveable	p	p	p	p	p						
Luminosity	p	p							?				
IR correct		p		p	p				b				
non-lin res	p	p	p	p	p				?		a, b		a
multipoles		p									a, b	a	
triplet roll		p							b				
sext calib		p							b				
dyn aper		p	p	?	?				b		a, b	a	a
halo	p	p	p						?				a
beam-beam	p	M turn	p	?	?		?		b		a, b		
working pt	p			?	?				a?				a
e-cloud				p	p				b			a	
IBS	p		p	?	?								
Instab		head-tail		p	p	p							
alpha one	p			?	?								
echo/diff	p	M turn	p	?	?		?						a
impedance		moveable		p	p	p	p		b	b		a	

Tune

- HFS Schottky
  - Linewidth at injection and store
  - Especially useful at transition
  - Motion control, improve S/N on local oscillator, improved DAQ
- Usefulness of LF Schottky w/ gold beams
  - For now, move to DSA's
  - Parallel HFS when time permits
  - Include tune data in GPM, archive
- MCR display with cursors for both. LabVIEW? App?
- PLL – motion control, improved S/N on LO, BW

Coupling

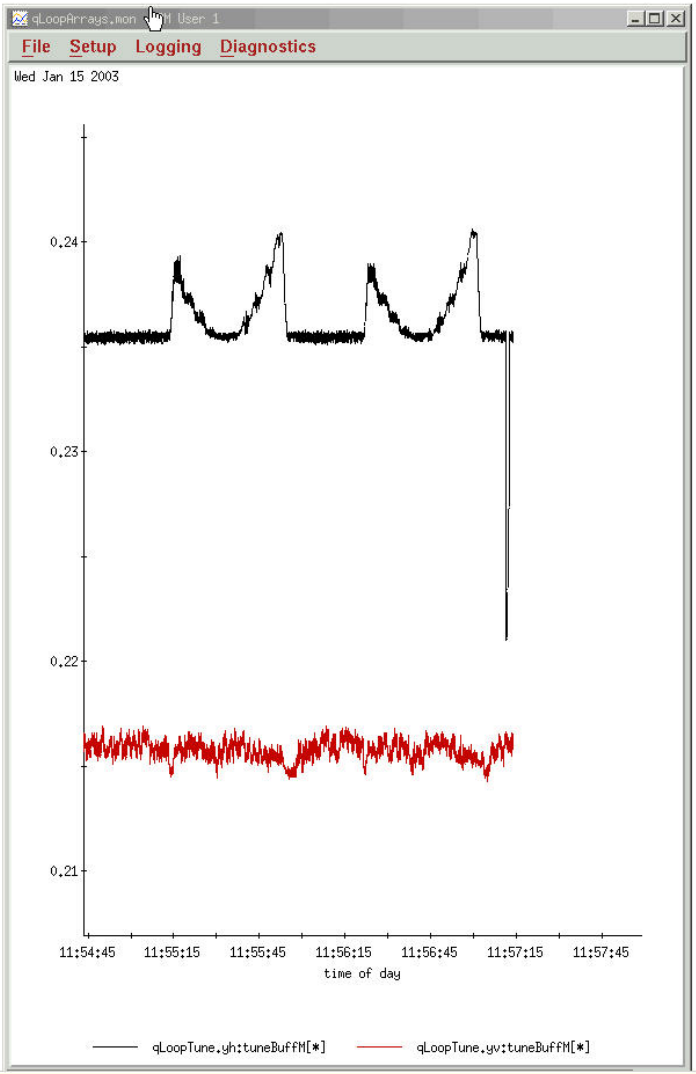
- Schottky - passive
  - For free from LFS, more difficult from HFS
  - Need GPM, include in Schottky
  - Motion control
  - Improved S/N
- PLL – skew quad modulation (Roser)
  - First efforts during last run's Beam Experiments
  - Small (~10-4) tune modulations give good signal
  - Supplement to Artus/BPM method when beam is kicked
  - Gives coupling when beam is not kicked

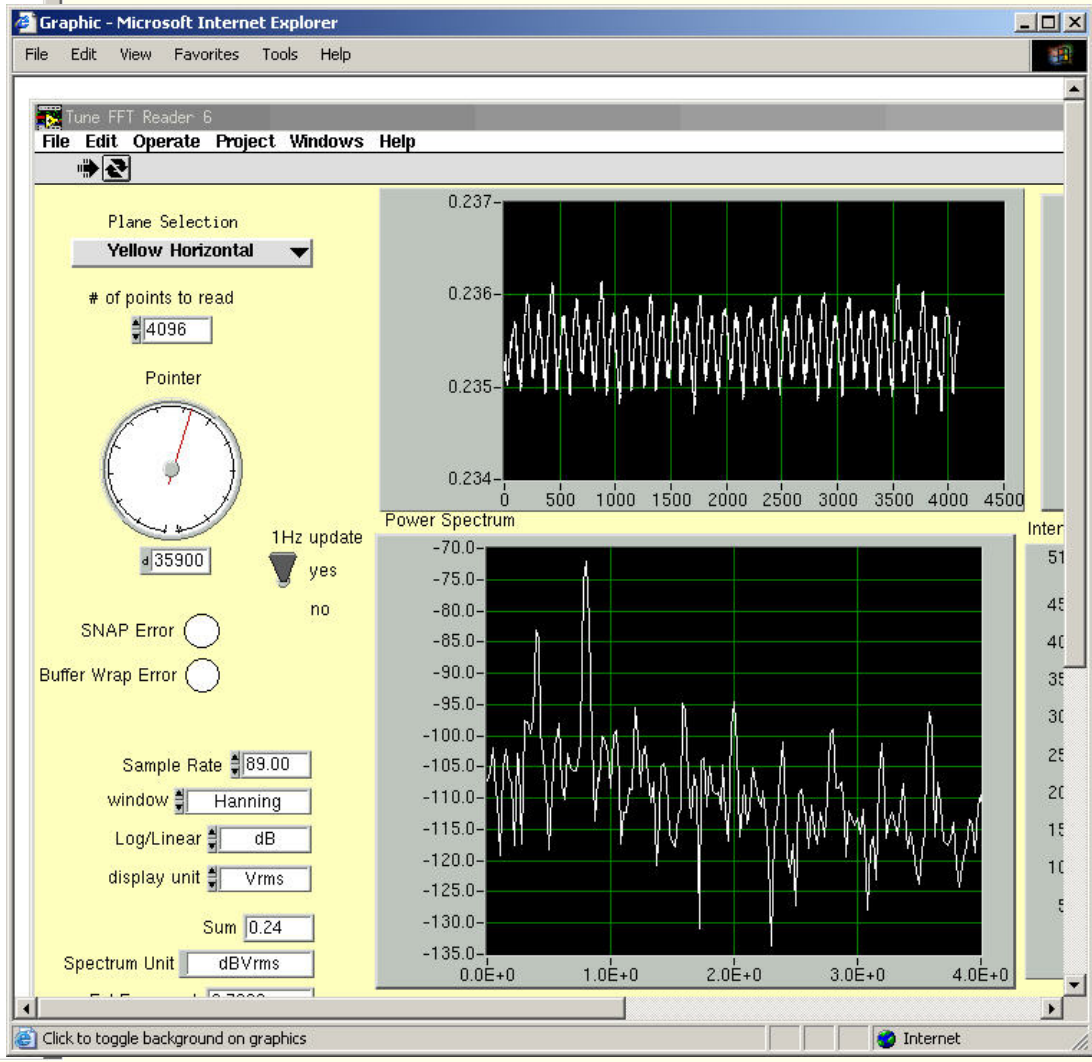

Tune FFT Reader 6
File Edit Operate Project Windows Help
Plane Selection
Blue Horizontal
# of points to read
2048
Pointer
26292
1Hz update
yes
no
SNAP Error
Buffer Wrap Error
Sample Rate 89.00
window Hanning
Log/Linear dB
display unit Vrms
Sum 0.25
Spectrum Unit dBVrms
0.247
0.246
0 250 500 750 1000 1250 1500 1750 2000 2250
Power Spectrum
-90.0 -95.0 -100.0 -105.0 -110.0 -115.0 -120.0 -125.0 -130.0 -135.0 -140.0 -145.0 -150.0 -155.0 -160.0
Intensi
550 500 450 400 350 300 250 200 150 100 50 0

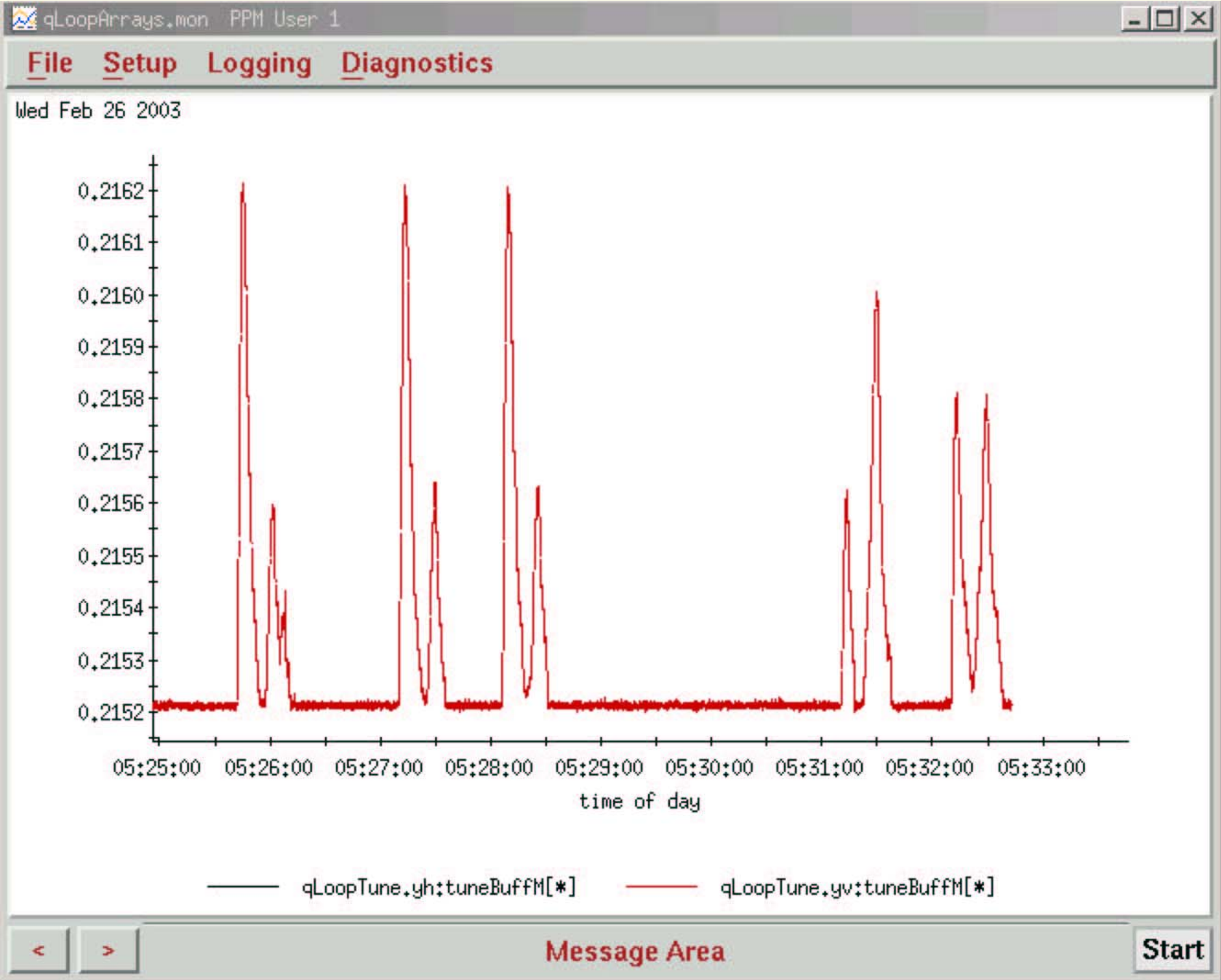
Chromaticity – linear, non-lin, skew

- Linear
  - For free from LFS, more difficult from HFS
- Non-linear
  - Primarily PLL, due to sensitivity
- Skew - Schottky's measure observables (eigenstates)
  - LFS – overlap generally not a problem, can measure H and V seperately
  - HFS as long as coupling keeps other lin >3dB below, can measure seperately
- A thought – modulate PLL phase to measure linewidth

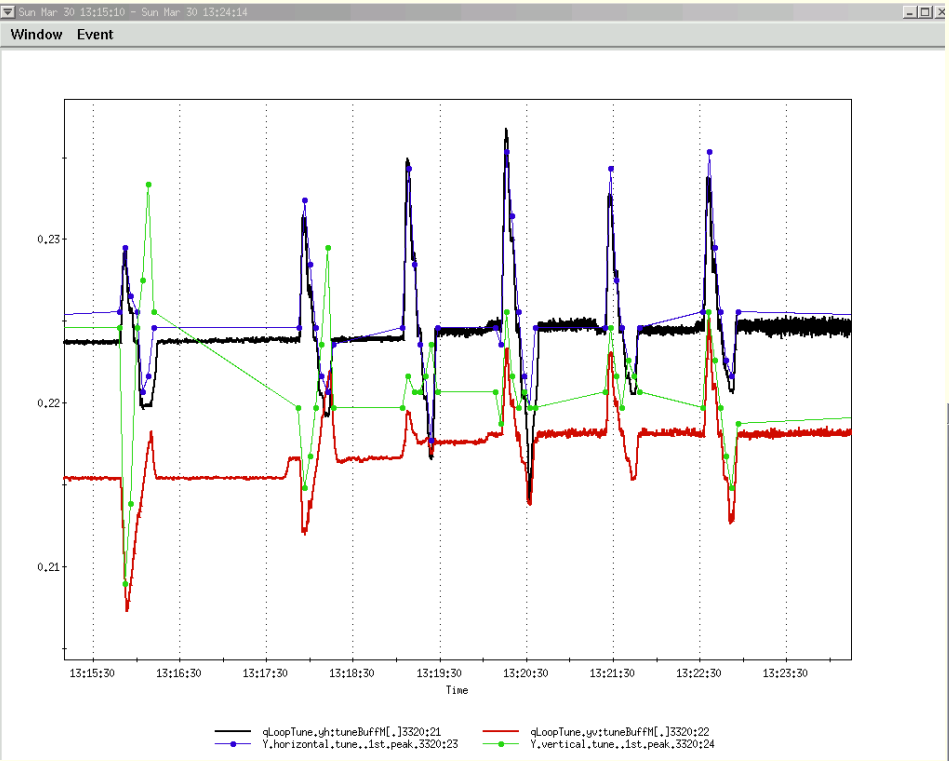
Non-linear chromaticity – .5Hz, .4mm



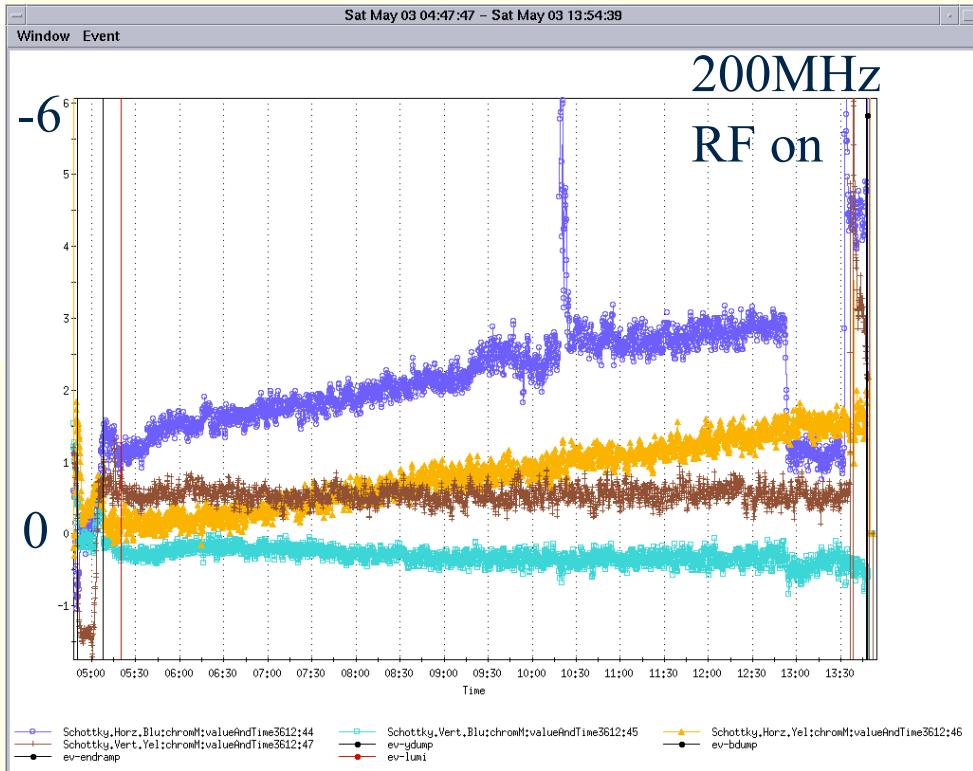



qLoopArrays.mon PPM User 1
File Setup Logging Diagnostics
Wed Feb 26 2003
0.2162
0.2161
0.2160
0.2159
0.2158
0.2157
0.2156
0.2155
0.2154
0.2153
0.2152
05:25:00 05:26:00 05:27:00 05:28:00 05:29:00 05:30:00 05:31:00 05:32:00 05:33:00
time of day
qLoopTune.yh:tuneBuffM[*]
qLoopTune.yv:tuneBuffM[*]
<
>
Message Area
Start

Chromaticity



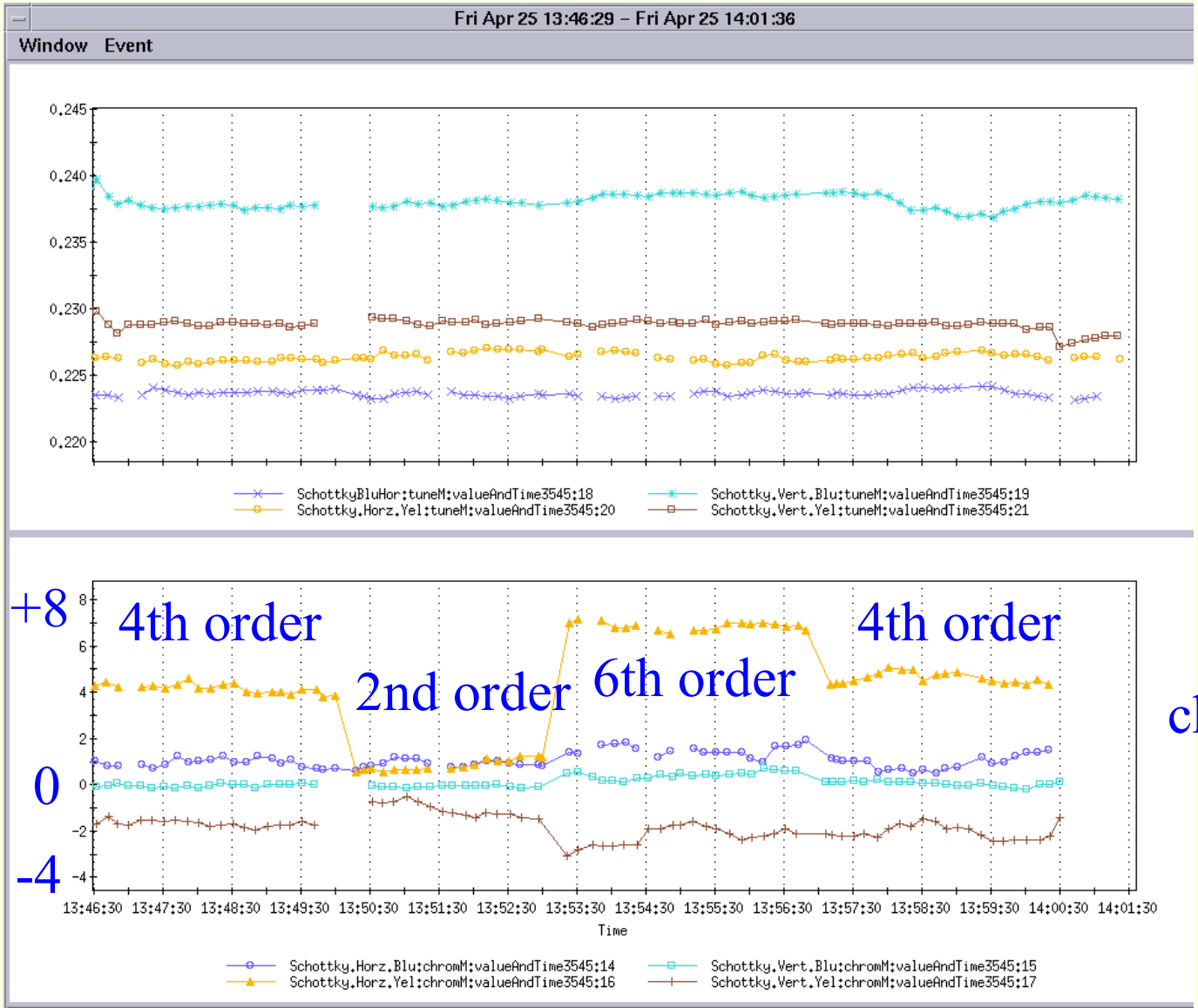
Chromaticity from kicked and PLL tunes

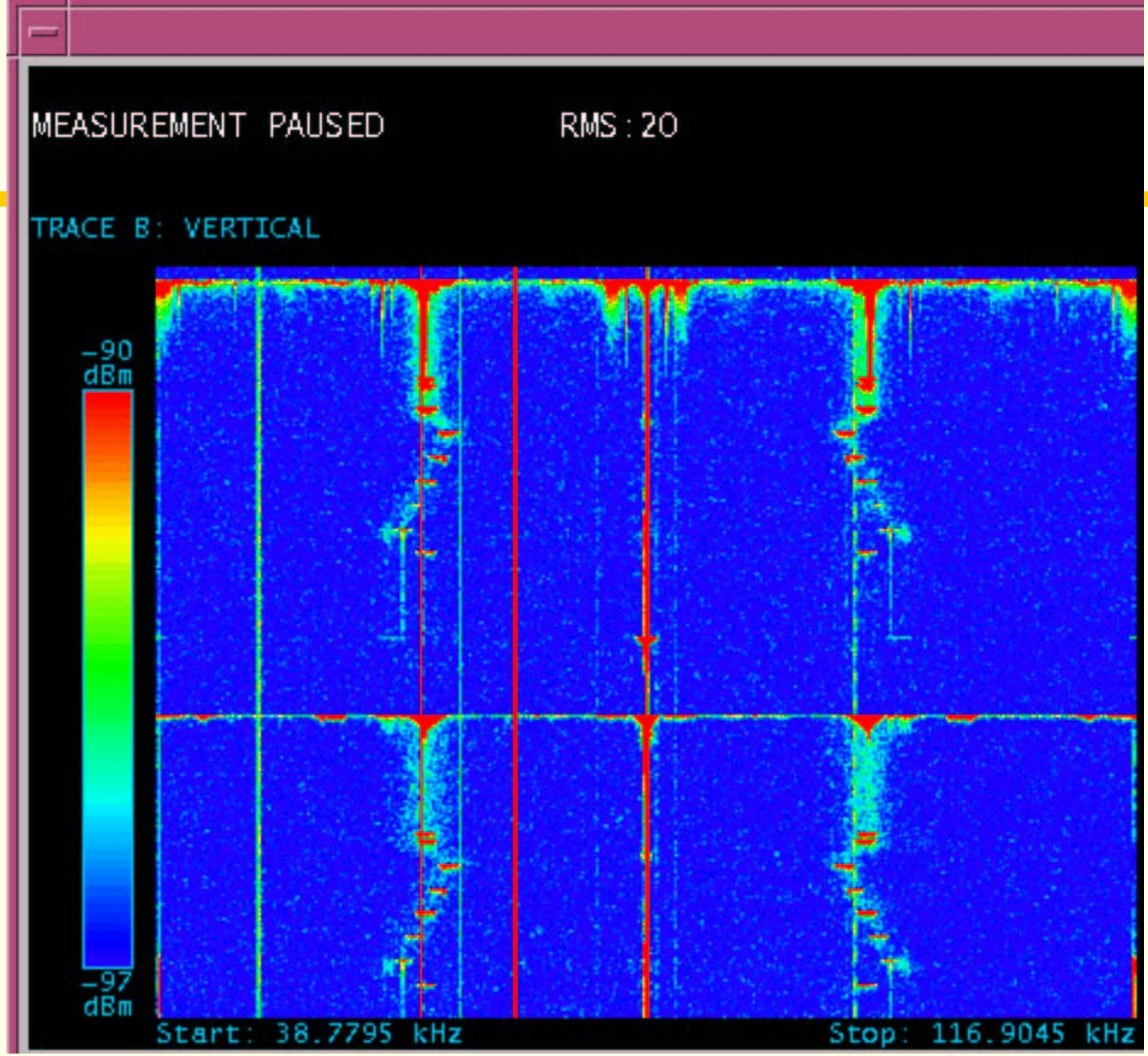


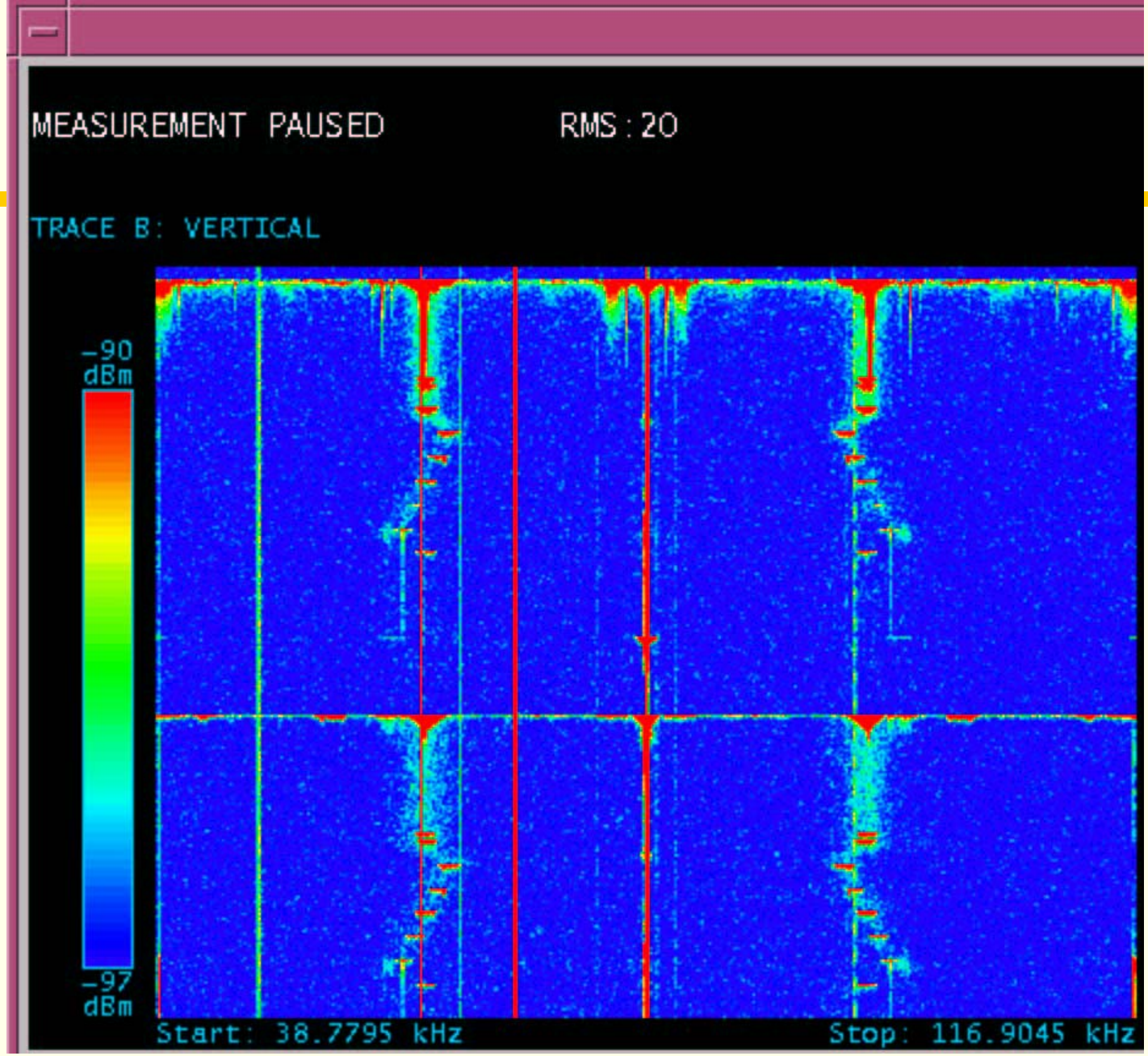
Chromaticity thru an 8hr store from Schottky

Beam Experiments Workshop

Fit Dependence of Chromaticity




MEASUREMENT PAUSED
RMS:20
TRACE B: VERTICAL
-90 dBm
-97 dBm
Start: 38.7795 kHz
Stop: 116.9045 kHz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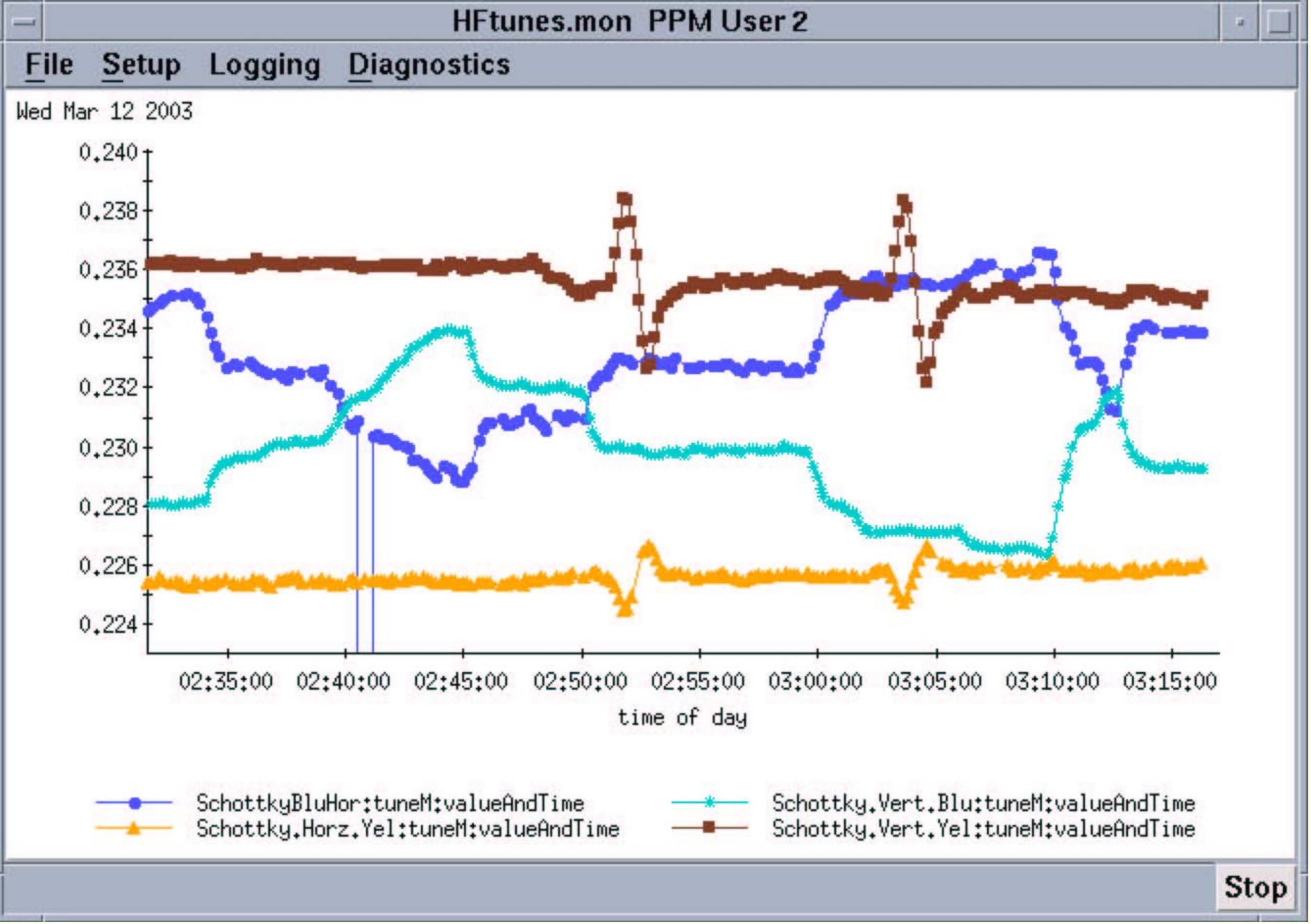
HFtunes.mon PPM User 2
File Setup Logging Diagnostics
Wed Mar 12 2003
0.240
0.238
0.236
0.234
0.232
0.230
0.228
0.226
0.224
02:35:00
02:40:00
02:45:00
02:50:00
02:55:00
03:00:00
03:05:00
03:10:00
03:15:00
time of day
SchottkyBluHor:tuneM:valueAndTime
Schottky.Horz.Yel:tuneM:valueAndTime
Schottky.Vert.Blu:tuneM:valueAndTime
Schottky.Vert.Yel:tuneM:valueAndTime
Stop

Beam-Beam

- Tools include HF Schottky, LF Schottky, Artus, PLL
- PLL measures incoherent tune (?)
- Short range beam-beam is incoherent
- Long range is coherent
- Beam steering to separate?
- Crab crossings mix short and long range
- Uncogged maximizes sensitivity for PLL
- Luminosity – use beam-beam transfer function?

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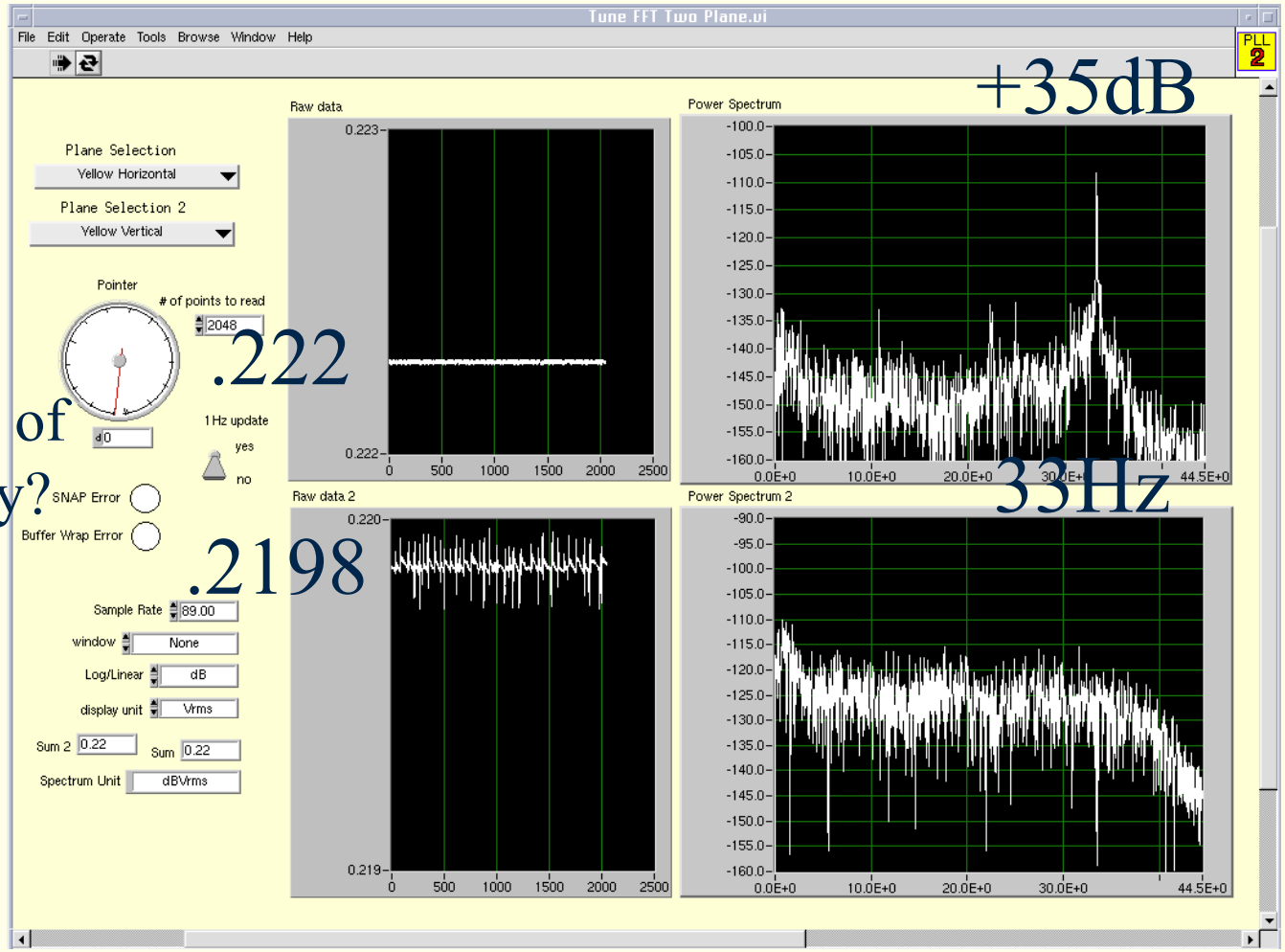
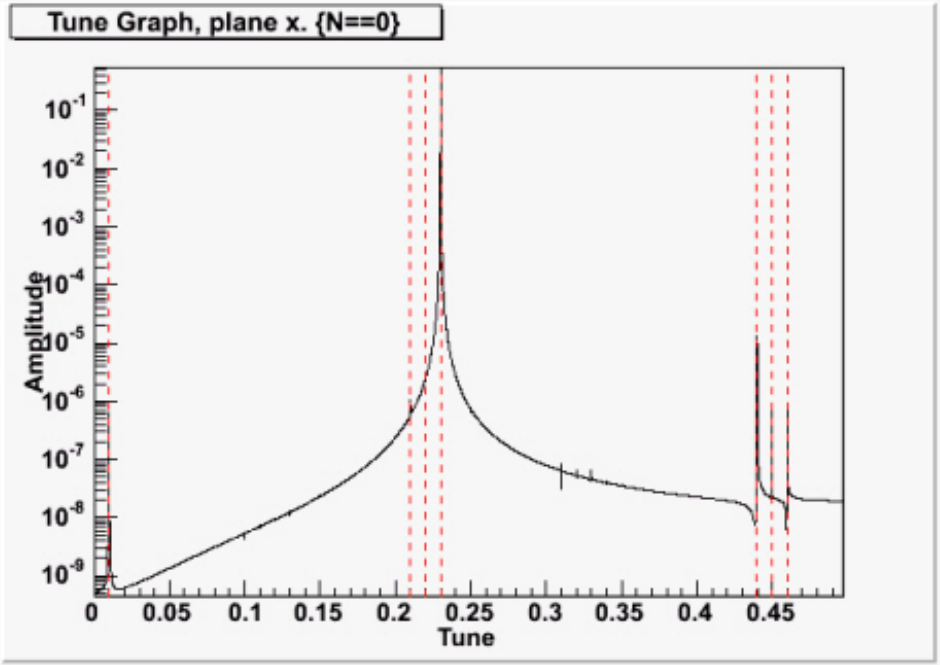
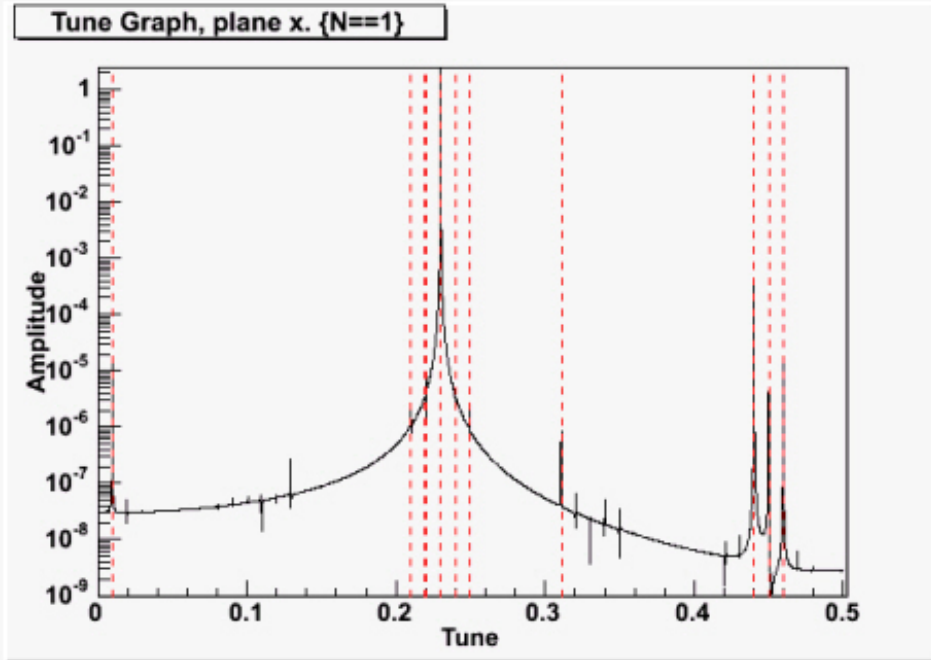
Island at 2/9 in RHIC?

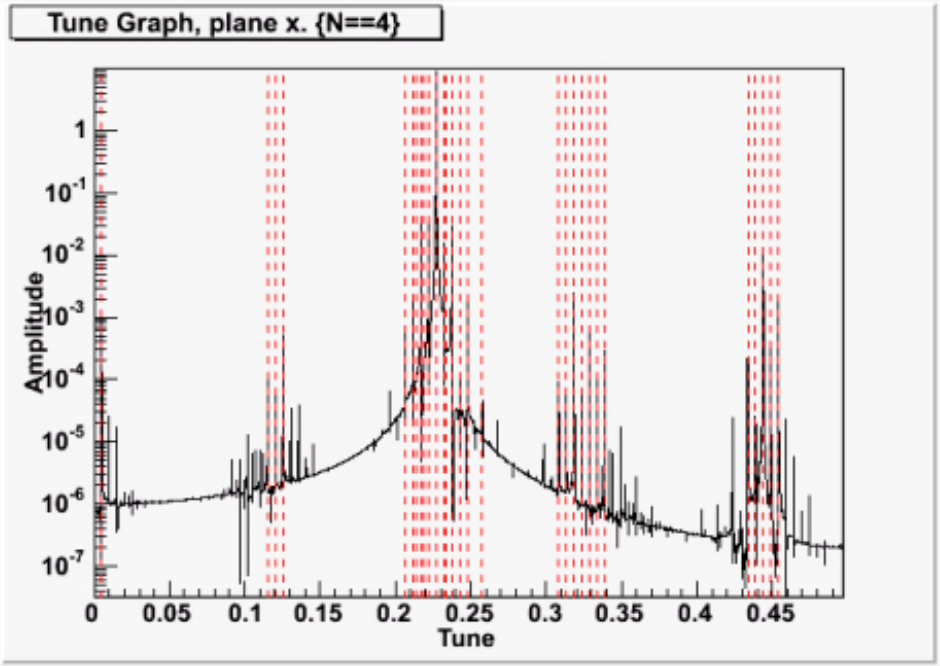
Kickers off

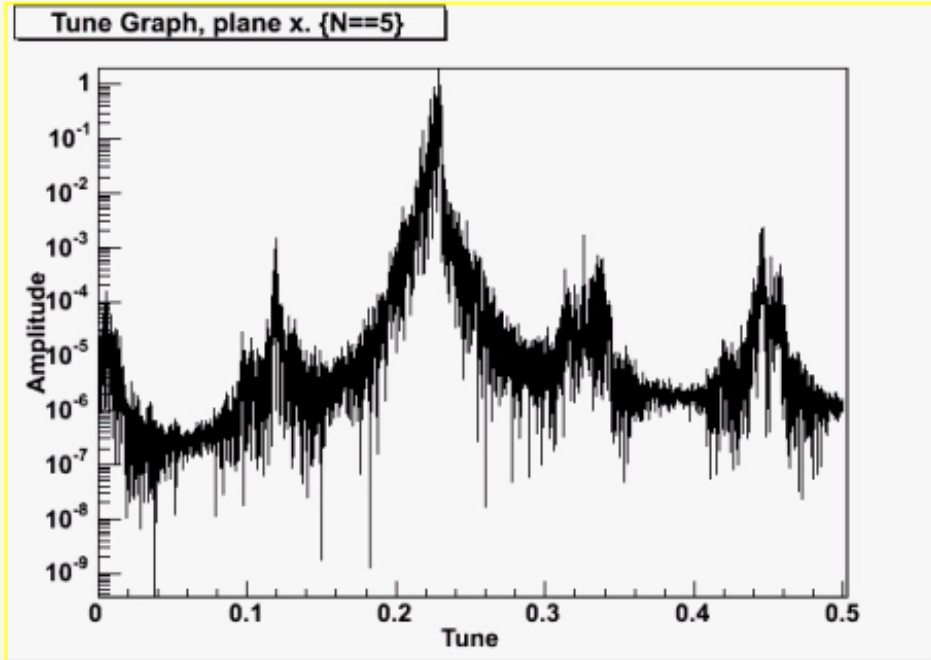
Position dependence of excitation frequency? resonance compensation?

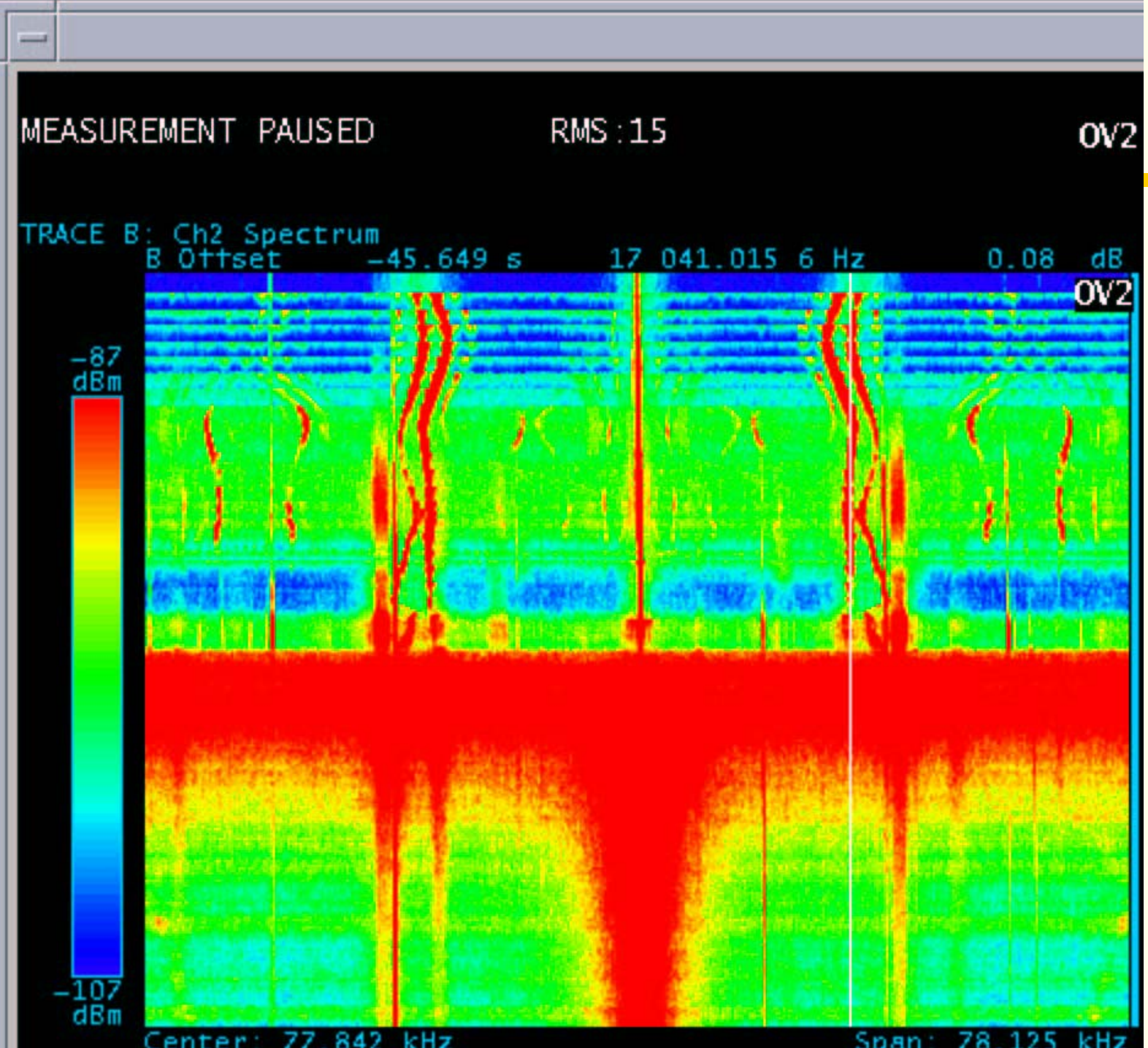



Tune Graph, plane x. {N==0}
Amplitude
Tune


Tune Graph, plane x. {N==1}
Amplitude
Tune


Tune Graph, plane x. {N==4}
Amplitude
Tune


Tune Graph, plane x. {N==5}
Amplitude
Tune


MEASUREMENT PAUSED
RMS:15
OV2
TRACE B: Ch2 Spectrum
B Offset -45.649 s
17 041.015 6 Hz
0.08 dB
OV2
-87 dBm
-107 dBm
Center: 77.842 kHz
Span: 78.125 kHz

Transverse Impedance

- Narrowband
  - PLL BTF uses resonant pickup, limited to ~245MHz
  - Incoherent tune has contribution from impedance
- Broadband
- With narrowband swept filter approach, losing the 20dB of gain from resonant pickup is acceptable
- Regular RHIC BPM is bolted to resonant BPM for centering. Use this pickup to measure broadband transverse impedance

Spectrum Analyzer

- We have modern state-of-the-art HP spectrum analyzer, LAN capable
- Connect to non-resonant moveable BPM? Buttons?
- Real-time transverse spectra available in MCR
- HP mux
- LabVIEW Interface for now

Outline by Experiment/Measurement

- Coupling - Skew quad mod, Line strengths (transition HFS)
- LFS – tune, coupling, spectral display (need lo)
  - Tune display ala FNAL 21.4 pickup (cursors, both real time and on archive…)
- Chrom - Non-lin HFS lineshape, phi mod PLL
- Skew Chrom
- Beam-beam – coh vs incoh, Lumi monitor
- MMB exp
- QTF
- IR correction
- Resonance compensation, Halo
- Echos, IBS,…
- Ampl dep tune shift – pll tune/I vs excitation – nonlinearities
- Impedance – shift of incoherent tune with beam steering? No, bunch intensity.

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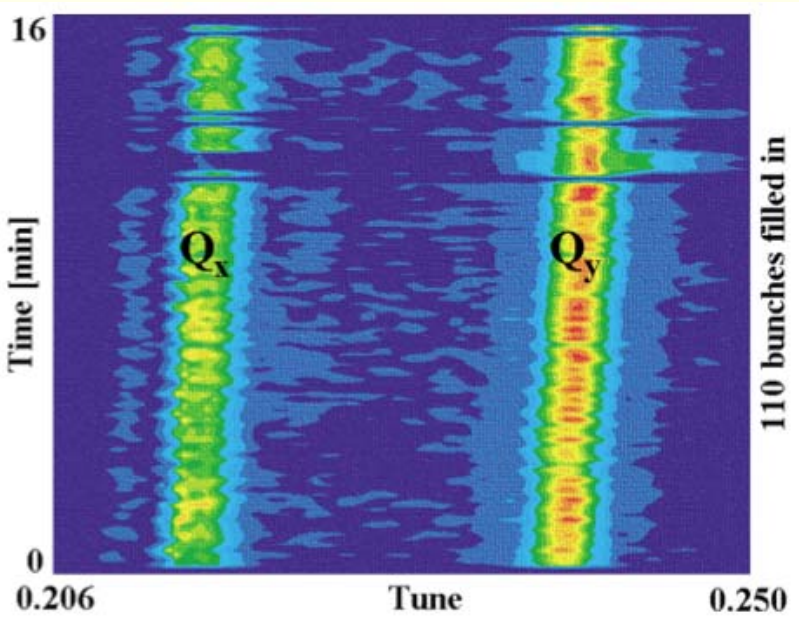
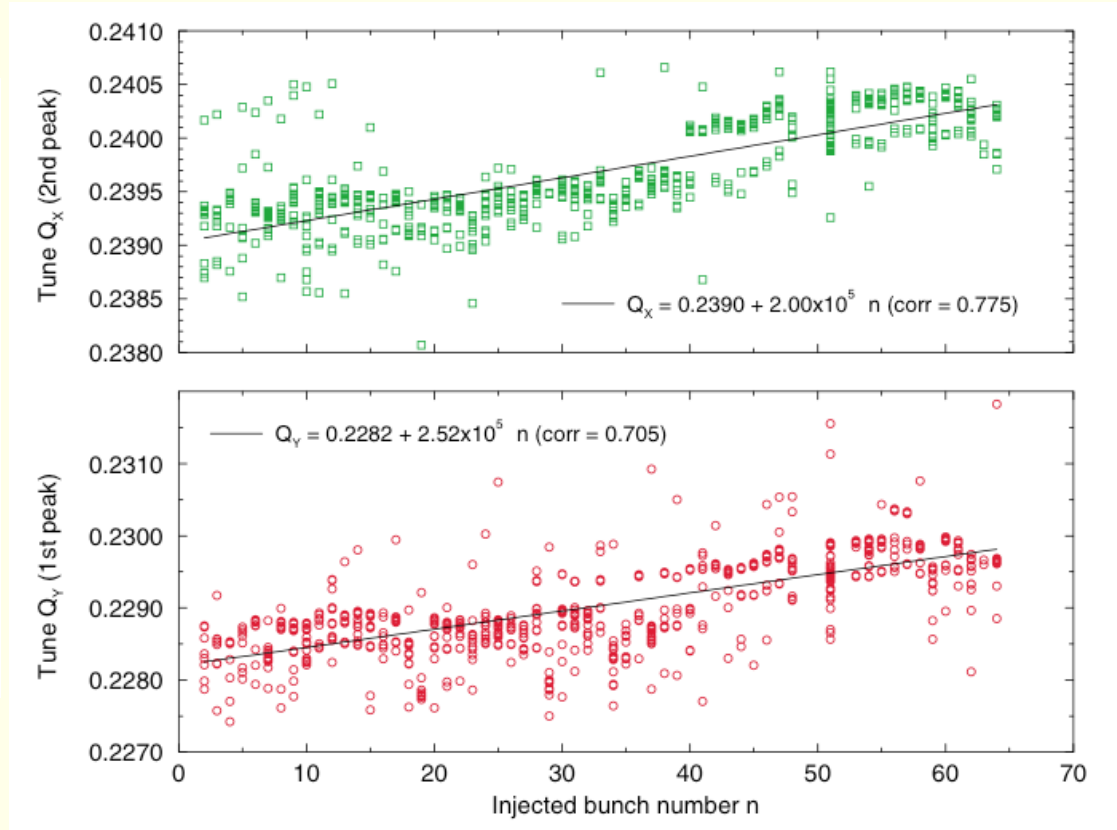
shift

W. Fischer et al





Emittance and deltap/p thru 16hr store